

Joining structure in a laminate comprising a local reinforcement

The invention relates to a joining structure in a laminate comprising metal layers as well as at least one adhesive layer which is enclosed by the metal layers, which metal layers each comprise separate metal-layer parts having a pair of overlapping edges, which pairs of edges are offset with respect to each other and together define a joining region.

A joining structure of this type is known and is found in panels whose width exceeds the width in which the metal layers are produced. Examples of panels of this type which may be mentioned include the skin panels of airplanes, for example those being used for the airplane's fuselage. In an application of this kind, the panels also have to be provided with apertures of a particular size. In this context, in addition to the apertures for windows, it is mainly the relatively large apertures, such as those used for doors and hatches and the like, which are relevant.

In theory, such apertures weaken the panel's supporting function. By applying local reinforcements, it is nevertheless possible to maintain the desired mechanical properties of the panel, such as stiffness and strength. Such reinforcements may be in the form of girders and joists, but in many cases the local reinforcements used are in the form of additional layers in the laminate, in the region of the aperture.

These local reinforcing layers are likewise made from sheet material having a particular maximum width and usually consist of the same material as the metal layers in the remainder of the laminate. The sheet material, which is usually supplied in the form of coils, is directionally sensitive with respect to its mechanical properties as a result of the manufacturing procedure. This directional sensitivity is caused, *inter alia*, by the direction of the rolling treatment to which the material is subjected. The rolling direction results in a grain orientation in the material.

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It is desirable to take the grain orientation into account when manufacturing panels from this type of material, in view of the desired mechanical properties of the said panels. In the present case, this means that the reinforcement layers must have the same

grain orientation as the metal layers in the laminate. The result of this is that in panels containing joins, the reinforcing layers must also have joins, since they cannot be provided in the longitudinal direction of the strip transverse to the joining structure, as the grain orientation would then be incorrect. These joins in the reinforcement layers 5 are preferably in close proximity to the joins in the laminate itself.

It is the object of the invention to provide a joining structure which meets the abovementioned requirements. This object is achieved by the fact that the laminate comprises a section which is of standard construction and a section which contains an 10 additional, internal reinforcing metal layer, said reinforcing metal layer comprising two reinforcing metal-layer parts with a pair of overlapping edges, said pair of edges being located outside the joining region and adjacent thereto.

With the joining construction according to the invention, the standard joining region in 15 the laminate is retained, while a join is nevertheless effected nearby in the reinforcing layer. These joins may be designed in various ways. Preferably, a metal-layer part of at least one of the metal layers has a joggled edge, in such a manner that the metal-layer parts are substantially in line with one another. This is a standard design for the panel which results in at least one side of the panel being completely flat, which is highly 20 desirable for aerodynamic reasons. In that case, each of the other metal layers as well as the reinforcing metal layer also has a joggled part.

Furthermore, in this case, a reinforcing metal-layer part may be joggled over the joggled edge of the joggled metal-layer part and then be joggled in the opposite 25 direction towards the other, associated metal-layer part. There are two possible variants with this kind of construction, and according to the first variant, the reinforcing metal-layer part is subsequently joggled in the same direction as said joggled edge of the joggled metal-layer part over the other reinforcing metal-layer part.

30 In this case, a metal-layer part of a further metal layer extends over the portion, joggled in the opposite direction, of the reinforcing metal-layer part to form a spacing between the edge of the metal-layer part and the portion, joggled in the opposite direction, of the reinforcing metal-layer part, in such a manner that the edge of the other metal-layer part

of the further metal layer extends as far as the region where this spacing occurs. The other metal-layer part is joggled from that region where this spacing occurs over the edge of the reinforcing metal-layer part joggled in the same direction and is then joggled in the opposite direction.

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According to a second variant of the construction described above, the non-joggled portion of the joggled reinforcing metal-layer part has an edge over which the edge of a further reinforcing metal-layer part extends.

10 The reinforcing metal-layer forms a relatively large thickening at its overlapping edges in the centre of the laminate. The problem which might occur in this case is that the covering metal layer would have to be given a joggled part of the same magnitude as the thickness of the overlapping edges of the reinforcing metal layer. However, a joggled part of this magnitude is somewhat undesirable, as this might cause porosity, 15 stress concentrations and local delamination. This can be avoided according to the invention if the edges of the reinforcing metal-layer parts, in the direction transverse to the direction in which the edges overlap, are of different sizes in order to provide a stepped joggle arrangement of the metal layer covering the reinforcing metal-layer parts.

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The invention will be explained in more detail below with reference to a number of exemplary embodiments shown in the figures, in which:

Figure 1 shows a plan view of a panel with a joining structure according to the invention.

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Figure 2 shows the cross section of the joining structure along II-II.

Figure 3 shows the cross section III-III of Figure 1 and Figure 2 of the joining structure.

Figures 4-6 show alternative embodiments of the joining structure according to Figures 1-3.

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Figures 7-9, 10-12, 13-15, 16-18, 19-21 and 22-24 show further alternative embodiments.

Figures 25 and 26 show alternatives for the position of the reinforcing metal-layer parts.

Figure 1 shows, in plan view, a panel 1 containing a joining structure 2. As shown in the cross section of Figure 2, the panel consists of a laminate comprising four metal layers 3, 4, 5, 6, each made up of metal-layer parts 7, 8. These metal-layer parts 7, 8 have overlapping edges 9 and 10, respectively, which are fixed to one another by a layer of adhesive 11.

One fiber-reinforced plastic adhesive layer 12 is arranged between in each case two of the metal layers 3 to 6. These fiber-reinforced plastic adhesive layers 12 are continuous and run on at the location of the overlapping edges 9, 10. The remaining spaces are filled with adhesive 13.

As can be seen in the plan view of Figure 1, the laminate comprises a section 14 of a standard design and a section 15 including an additional reinforcing metal layer 16. This additional reinforcing metal layer 16 comprises two reinforcing metal-layer parts 17, 18 with the respective overlapping edges 19, 20 which are glued together by the layer of adhesive 21.

As can be seen in Figure 2, these overlapping edges 19, 20 of the reinforcing metal-layer parts 17, 18 which are fastened together are outside the area in which the overlapping edges 9, 10 of all metal-layer parts 7, 8 are fastened together.

Furthermore, it is important that the metal layer parts 7 are provided with a joggled edge 9 in such a manner that the sections 22 are offset with respect to the associated edge 10 of the other metal-layer part 8. This means that one surface 30 of the laminate is flat, which is particularly important in aerodynamic applications of the panel. All metal layers 3, 4, 5 and 6 contain the sections 22.

As illustrated in Figure 2, the reinforcing metal layer 16, in particular the reinforcing metal-layer part 17 thereof, is provided with a corresponding joggled section 26. The reinforcing metal-layer part 17 then continues over the joggled edge 9 of the metal layer 5, followed by a section which is joggled in the opposite direction in such a manner that the metal-layer part 17 is subsequently glued to the metal-layer part 8 of

the metal layer 5 beneath it by means of the respective fiber-reinforced plastic adhesive layer 12 along the section 27. This is then followed by the joggled edge 19 of the reinforcing metal-layer part 17.

- 5 As a result of the flanges 24, 25 of the reinforcing metal-layer part 17, a spacing has been created between the upper metal layer 6 and the reinforcing metal-layer part 17. The space which has thus been created contains the edge 10 of the reinforcing metal-layer part 8 of the metal layer 6.
- 10 The cross section III-III of Figures 1 and 2, as represented in Figure 3, shows that the reinforcing metal-layer parts 17, 18 continue for different lengths in the direction parallel with the edges 9, 10 and 19, 20, respectively. The reinforcing metal-layer part 17 extends over the other part 18 and is joggled as far as the metal layer 5 beneath it. This has the advantage that the metal-layer part 8 of the upper metal layer 6 is 15 gradually joggled in two stages 28, 29, so that metal-layer part 8 is not subjected to sudden joggled part of a relatively great magnitude, thus counteracting delamination and porosity.

- 20 The joining structure according to the invention can be constructed in many different variants, some of which are illustrated in the Figures 4-26, which will be discussed below.

- 25 The variant of Figures 4-6, which figures show views and cross sections corresponding to those of Figures 1-3, is a variant in which, in the cross section V-V, the reinforcing metal-layer 18 has a joggled edge 19, under which the flat overlapping edge of the reinforcing metal-layer part 17 extends. As the reinforcing metal-layer part 17 extends further than the reinforcing metal-layer part 18, as illustrated in Figure 4, a step-like sequence of these overlaps has been achieved in cross section VI-VI.

- 30 The variant of Figures 7-9 is to a large extent identical to that of Figures 1-2, except that here the reinforcing metal-layer part 18 extends further than the reinforcing metal-layer part 17, as can be seen in Figure 7. Reinforcing metal-layer part 17 again has a flat edge 19 like the variant of Figures 4-6, whereas the reinforcing metal-layer part 18

has a joggled edge 20. This results in the cross section IX-IX where the reinforcing metal-layer part 18 has been joggled downwards as far as the metal layer 12.

5 The variant of Figures 10-12, which corresponds to a large degree to that of Figures 7-9, has a reinforcing metal-layer part 18 with a flat edge 20, whereas the reinforcing metal-layer part 17 in this case has a joggled edge 19. This results in the step-like configuration of the reinforcing metal-layer parts 17, 18 in the cross section XII-XII.

10 The variant of Figures 13-15 differs from the previous variants in the sense that the reinforcing metal-layer part 17 has a flat edge 19, whereas the reinforcing metal-layer part 18 has a relatively long joggled edge 20. Therefore these edges 19, 20 now overlap on the left-hand side of the joining region 2, rather than on the right-hand side of this joining region 2 according to Figures 1-12 (as illustrated in Figures 2, 5, 8, 11 and 14, respectively).

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In the variant of Figures 16-18, the reinforcing metal-layer part 18 is joggled over the joggled edge 9 of the metal layer 5 at 23 and is followed by a joggled portion 26 which is glued to the metal layer 6, in particular the metal-layer part 7 thereof. The reinforcing metal-layer part 18 is then joggled in the opposite direction at 24. The joggled edge 19 of the other reinforcing metal-layer part 17 is arranged on the edge 20 of the reinforcing metal-layer part 18 and, in addition, the overlapping edges 19, 20 are located on the left-hand side of the joining region 2.

20 The variant of Figures 19-21 corresponds to a large degree to that of Figures 13 to 15, except that in this case the reinforcing metal-layer part 17 extends further than the reinforcing metal-layer part 18, as is illustrated in the plan view of Figure 19.

25 In this way, the variant of Figures 22 to 24 corresponds to that of Figures 16 to 18: in this case the reinforcing metal-layer part 18 also extends less far than the reinforcing metal-layer part 17.

30 Figures 25 and 26 illustrate that the reinforcing metal-layer parts 17 and 18 may be situated at any location in the thickness between the metal layers 3, 4, 5 and 6.